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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, 14, Trinity Square, London, E.C. 3, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

WEST INDIAN FRUIT AND VEGETABLES.

DURING the past few years considerable developments have taken place in the production of fruit and vegetables in the British West Indies. In view of the plight of certain major agricultural industries, this expansion has to some extent been accelerated by the need for seeking new scope and outlets for agricultural produce. It has also been due more recently to the presence, both in Canada and the United Kingdom, of protected markets capable of absorbing increasing quantities of West Indian fruits and vegetables. In arriving at the present stage it may be claimed that many difficulties have been overcome in a comparatively short time. The growth of the new industries has so far been mainly concerned with the preliminary organisation of production and marketing. Much has been done, for instance, to regulate uniformity in quality and packing and to organise the disposal of produce in the Canadian markets. With the financial assistance received from the Colonial Development Fund packing sheds have been erected in many of the Colonies and cold storage facilities provided. The formation of co-operative societies for the handling and disposal of produce has also been encouraged wherever possible. In addition, much useful advice has been received, particularly in the Leeward and Windward Islands, from the Marketing Officer whose appointment was a direct outcome of the St. Lucia Fruit Conference. This Officer has supervised the grading and packing of fruit and vegetables in these islands, organised the purchase of packing materials, assisted in the marketing of West Indian produce through recognised firms of brokers in Canada and has helped to secure uniformity in legislation dealing with the fruit and vegetable trade. A visit paid to Canada enabled him to collect valuable information regarding the market requirements of that Dominion. Several Departmental Officers have also paid visits from time to time to the North American Continent and elsewhere to study conditions on the spot and have returned with a fund of useful information. In Trinidad the Citrus Growers' Association, by engaging as its Manager an expert from Florida to supervise the packing of fruit, has shown its determination to place only the best quality product on the market. Thus, it will be seen that no pains have been spared to set up as effective an organisation as possible to deal with the fruit and vegetable industries, established or potential,

of these Colonies. The results so far obtained have been gratifying but before these industries can take an adequate stand against foreign and Empire competition many problems still require to be solved. Amongst these may be included that of the limitations of markets and particularly of the Canadian markets which have already shown tendencies of becoming glutted for certain classes of produce. It has also been stated that the possibility of working up business in other directions in Canada has not been fully realised in all centres of production. Unless arrangements for closer co-operation are made, between the several West Indian Colonies there is, moreover, the danger of inter-island competition for the new trade. It was precisely for the purpose of discussing these and other problems that a West Indian Inter-Colonial Fruit and Vegetable Conference was recently held in Jamaica.

This Conference which was called by the Secretary of State for the Colonies was fortunate in being very strongly represented, by delegates from all parts of the British West Indies. In particular the services of the Agricultural Adviser to the Colonial Office were especially secured for the occasion. The broad terms of reference included the examination of the present position of the West Indian Fruit and Vegetable industries and the consideration of the formulation of a co-ordinated policy for their further development. Among the subjects discussed were the present position in regard to particular crops, the rationalization of production and export, market organisations, representation in Canada, the standardisation of products, legislation relating to Fruit and Vegetable exports, shipping facilities, cold storage, freight rates, fruit preservation and canning.

With regard to particular crops the extension of grapefruit cultivation was recommended in view of the availability of protected markets for that fruit in the United Kingdom and Canada. It was advised that 75 per cent. of future plantings should consist of budded plants of the Marsh variety and that the remainder should be confined to the Foster and Duncan varieties until experimental work by Government Departments of Agriculture had established the superiority of any other varieties for the early and late markets. Indications that additional quantities of oranges could be absorbed by Empire markets, particularly during the early and late months of the West Indian season led to the suggestion that the cultivation should be restricted to those localities which were most suited for the production of early and late fruit. The fruit should be of the best standard varieties and of the highest quality, commercial plantings being confined to the late Valencia and the Parson Brown varieties and, for suitable localities, the Washington Navel. The lime industry having lost its markets for citric acid and, to a certain extent, for raw juice was considered to be practically dependent on the demand for essential oil and fresh fruit. The outlet for fresh fruit, however, is at present almost entirely confined to the United States and Canada and both these markets appear to be limited. In view of this and of prospective increased production from recently established cultivations in certain West Indian Colonies and the Gold Coast it was recommended that each Government should adopt measures, until there was a material alteration in the outlook, to restrict further plantings of this crop. The prospects for the citrus industry, except in the instance of limes, may therefore, be regarded as promising.

It was urged that efforts should be directed towards the production, if possible, of supplies of British West Indian tomatoes during the months of March to June for the Canadian markets. Since the Colonies at present engaged in tomato production for these markets are unlikely to increase their shipments during the period mentioned, it was suggested that Trinidad and Jamaica might be able to produce this commodity during the Spring months. Such production is not, however, to be attempted on a commercial scale until Government Departments of Agriculture have had the opportunity of investigating its possibilities. There does not appear to be any great prospects for a trade in British West Indian tomatoes on the United Kingdom markets.

The London market for mangoes, although a small one, appears to be most promising. It was advised, however, that only the best quality fruit should be shipped, the varieties recommended being the Jamaica Bombay for dry areas, and the Julie for wetter conditions. There is also a small demand in the United Kingdom and Canada for avocado pears but extension of planting was not recommended until more definite information was available regarding varieties, with particular reference to cold storage reactions, packing and ripening. It was urged in the case of mangoes, avocadoes, papaws and melons, that the Imperial College Low Temperature Research Station should be invited to undertake storage investigations on problems germane to the shipment of these fruits and that similar investigations should be undertaken with vegetables whose cultivation could be profitably undertaken in the West Indian Colonies. Among these, sweet potatoes, peppers, cucumbers, egg plants, string beans, christophines and West Indian shallots were mentioned for special consideration.

The attention of Departments of Agriculture was drawn in particular to the need for extending production and marketing investigations, testing varieties showing particularly desirable characteristics, ascertaining those best suited for cultivation and export and for selecting suitable strains of planting material. Recognising the desirability of establishing machinery for the collection and dissemination of information derived

from these investigations the Conference recommended that a clearing house should be established and that a West Indies Fruit and Vegetable Bulletin should be issued at such intervals as might be found necessary. It was considered that the most suitable body to act as the clearing house and office of publication for the Bulletin would be the Imperial College of Tropical Agriculture, respective Departments of Agriculture supplying information as it became available.

With regard to the question of the allocation of definite seasons to particular islands it was considered that since a natural control of seasons already existed through climatic and other natural influences, there was no apparent need for the moment to consider any inter-colonial control. There appeared, furthermore, to be no necessity at present to consider the question of the allocation of markets on a quota system nor to attempt to restrict the production of the crops reviewed with the exception of limes.

The Conference was of the opinion that the co-operative movement was essential for the successful organisation of the Fruit and Vegetable industries in the West Indies and recommended that its extension in the form of local co-operative associations should be encouraged in each colony where the development of these industries appeared practicable. Where Government Marketing Agencies had been established it was suggested that the final objective should be the establishment of co-operative associations for the handling and disposal of fruit and vegetable exports. Moreover, as much benefit had been derived in certain Colonies from the collective purchasing of supplies, it was recommended that this service should be rendered by Government Marketing Agencies or by Co-operative Associations.

The need for a uniform policy to enable the British West Indian Colonies as a whole to develop their agricultural resources to the fullest advantage was one of the chief matters discussed at the Conference. In this connection it was recommended that two West Indian Fruit and Vegetable Councils should be established, one for the Eastern Group comprising British Guiana, Trinidad, the Windward and Leeward Islands, Barbados and Bermuda, with headquarters in Trinidad, and one for the Western Group, consisting of Jamaica, British Honduras and the Bahamas, with headquarters in Jamaica. It is hoped that these Councils will collect and publish information regarding the commercial aspects of the fruit and vegetable trade, encourage co-operative movements in individual Colonies and amongst the Colonies, direct the marketing intelligence service and administer funds raised for collective advertising.

Another important recommendation was that relating to the suggestion that a Marketing Intelligence Officer should be appointed in Canada to look after the interests of the fruit and vegetable industries of the West Indian Colonies in that Dominion. The general direction of this service is to be entrusted to the two Councils already referred to but the Officer will be required to communicate general marketing information direct to the Governments and trading interests of the Colonies.

Other recommendations relate to the standardisation of products, legislation, shipping facilities, advertising and canning. Various grades for certain products and the use of special packing materials and labels were recommended. Produce will be labelled to show that it originates not only from the British West Indian area but also from a particular Colony in that area. The details of a Fruit Exportation Ordinance were worked out to ensure the exportation of only high grade products. Tribute was paid to the Canadian National Steamships for the manner in which they had met the requirements of the trade. It was hoped that collaboration of steamship companies in assisting with experimental shipments would be extended and that cold air-blast systems instead of still cold storage chambers would be provided in the future. Readjustments of freight rates for low valued products appeared to be necessary and a reduction of rates to the United Kingdom was urged. With regard to advertising it was proposed that a sum of £2,000 per annum should be collected for this purpose by asking growers to contribute a charge per package varying according to the class of produce, and the Governments concerned to make grants equivalent in amounts to the contributions made by their respective exporters. In view of the fact that the industries cannot at present bear the cost of an extensive and direct advertising campaign the use of existing organisations and of inexpensive methods of advertising was advocated. With regard to canning it was believed that the canning of grapefruit by small factories might be developed with some prospects of success and that local canning might be encouraged for domestic consumption. The canning of pineapples was an industry which it was thought should be considered with great caution and before any further development was contemplated the results of the British Guiana project should be awaited.

The recommendations made at this Conference provide ample evidence that much good work has been accomplished. The full Report of its proceedings should be read by all those interested in the industries with which it is concerned, especially as it contains much detail information of a practical nature. The need for co-ordination was fully realised and it will be seen that the Conference lost no time in drafting resolutions calculated to stress its importance. When the measures advocated are put into effect they should go a long way to advance that co-operative spirit so essential to the ultimate success of the West Indian Fruit and Vegetable industries.

BANANA STORAGE.

An account of investigations into the storage behaviour of several varieties.

By C. W. Wardlaw and L. P. McGuire.

[*The following is a précis of a Report on Banana Storage Investigations recently published by the Empire Marketing Board.*]

Introduction.

In recent investigations at the College Low Temperature Station, further storage trials have been undertaken with a number of banana varieties to determine their behaviour under commercial conditions and to assess their value and suitability for export. In these experiments the following varieties, in large or small quantities as material became available, were kept under observation: the Giant Governor; the Trinidad Governor or Cavendish variety; various Cavendish types; Fillbasket; Gros Michel; the College Hybrids I.C.1 and I.C.2; an assemblage of tall types including the Giant Fig, Lacatan, Bumulan, Martaban and Masak Hijau.

The Giant Governor.

This interesting variety, locally known as the Giant Governor, is apparently a tall sport or mutant derived from the ordinary Dwarf, Cavendish or Governor variety.* In the field, under average conditions, it is a plant of intermediate stature, much taller than the Dwarf, but definitely not so tall as the Gros Michel or Giant Fig. The stout trunk or pseudo-stem is strongly reminiscent of the Dwarf variety from which it is thought to have originated, Fig. 1.

The fruiting characters show some points of interest. Immediately below the female flowers there is a region of the fruit stem from which the male flowers and bracts drop off, Fig. 2, but lower down near the compact bud, adherent bracts are again encountered. In general, though not in all cases, the bunch habit shows some departure from the normal Dwarf type: as a whole it tends to be more cylindrical, the vertically upturned hands being less spreading, Fig. 3. The fruit skin is also more resistant to mechanical injury. In short, other things being equal, the bunch habit is much more suitable for naked bulk transport than the ordinary Dwarf type.

The fruit used in these investigations was obtained from a Maqueripe estate. Side by side in the same area, a light sandy loam, the Trinidad Governor or Dwarf variety has also been planted. Although both received the same manurial treatment, namely, a basket of pen-manure at the time of planting, the response of the two varieties was very different indeed. In the case of the Governor variety, bunches of moderate size only were obtained, whereas the Giant Governor responded vigorously and has consistently produced remarkably fine, well-developed bunches. Experience will show whether this holds good for other soil types also.

So far, four bulk storage trials have been carried out with the Giant Governor, the Dwarf or Trinidad Governor from the same and other areas being included for comparison.

From these storage trials, which are described in detail, it appears that the Giant Governor may be regarded with a certain amount of optimism. On soil which could not be regarded as being suitable for the Gros Michel, the Giant Governor produces large well-developed bunches. These are cylindrical in shape and the disposition of the fingers is such as to permit of naked stowage in bulk without undue loss through mechanical injury. Further, such fruit as has been available for experimental purposes possesses a much tougher skin than the ordinary Cavendish or Governor variety, and accordingly bunches suffer less from superficial bruising and scarring. In this respect, however, it cannot be claimed that the Giant Governor is the equal of the Gros Michel. This is partly due to the constitution of the skin in relation to wounding or bruising and partly to the fact that fruits of the Cavendish group are inherently more subject to fungal attack than those of the Gros Michel.

Disadvantageous characters in the Giant Governor are concerned with questions of maturity and the temperature factor.

Even where a long period in cold storage is anticipated, fruit must not be reaped until it is heavy and almost fully developed. Instead of reaping at "¾-full" as in the Gros Michel, Giant Governor bunches for transport to English or European markets should be "heavy ¾-full" or almost "full," otherwise delay and irregularities in ripening will certainly be experienced later. Such heavy bunches are not only liable to receive rather rougher handling, but as the individual fruits are of very large size they may prove less acceptable to certain markets.

With regard to the second factor, this variety requires a higher storage temperature—not lower than 56°F.—than is at present customary in the trade, and this may prove a difficulty, particularly in the inaugural stages when mixed consignments would have to be carried. Given careful handling and storage and suitable protection against mainstalk rot, however, fungal wastage need not become excessive, even though fruit is being carried at a higher hold temperature.

* For an account of mutant types of the Dwarf banana, readers should consult Professor E. E. Cheesman's paper (1).

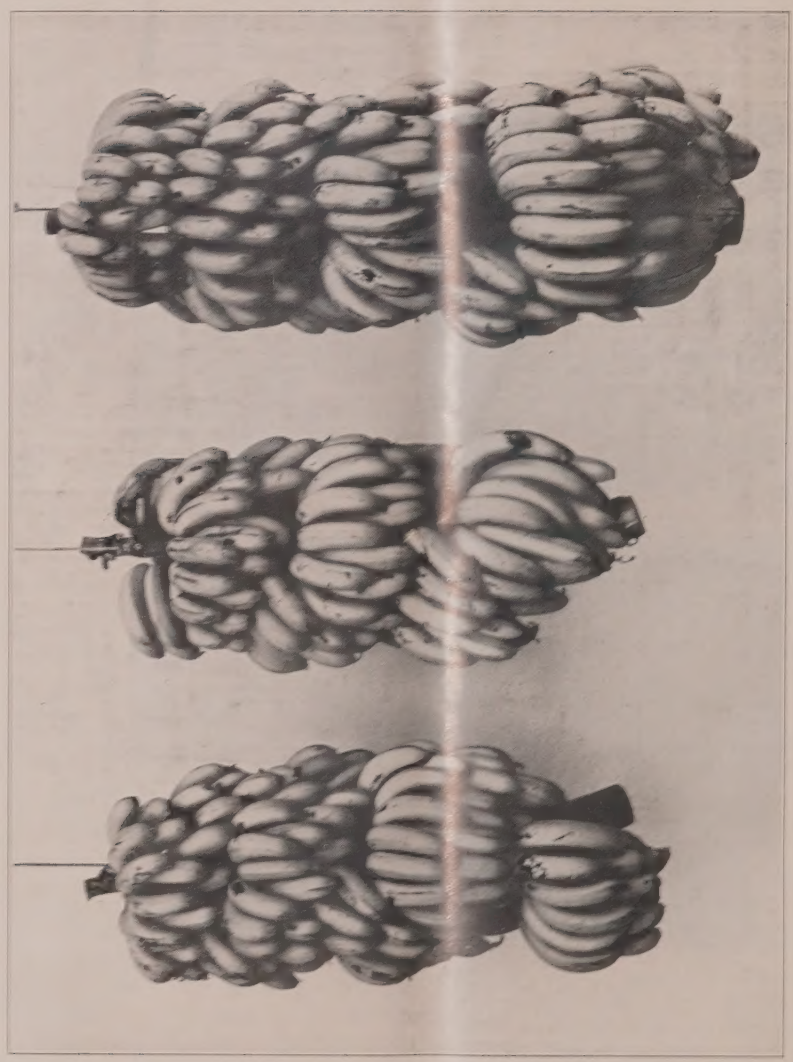
BANANA STORAGE.

FIG. 1.—*Giant Governor plant with half-full bunch. Note stature of plant.*

FIG. 2. — *Young bunch of Giant Governor. Note its cylindrical shape.*

(*Figs.* 1 *and* 2 *by courtesy of Messrs. F. W. and P. Urich.*)

BANANA STORAGE.



Tucker Picture Co.

FIG. 3.—*Good commercial bunches of Giant Governor, reaped at the correct stage of maturity for transport to British and European Markets. (Two nine-hand bunches and one eleven-hand bunch.) This photograph was taken when bunches were being removed to the ripening room.*

From the strictly scientific point of view these studies should only be regarded as being of a preliminary nature. As supplies of fruit become available, further investigations should take into consideration the influence of different soil conditions and of different seasons on storage behaviour, the relative merits of ratoon versus plant bunches, the influence of manurial treatments, criteria of maturity to achieve greater uniformity in consignments, the effect of ripening at different temperatures and so on.

Before the final assessment of commercial suitability can be made, shipping trials must be carried out and the fruit, subsequently handled and distributed through the usual channels, must meet with the approval of the public palate. It is to be hoped that such trials will be carried out under suitable supervision when larger supplies of fruit become available.

The Dwarf, Cavendish or Governor Variety.

By way of amplifying the observations on this variety already submitted (2), several consignments were taken into storage and held at 53°F.

(1) for comparison with the Giant Governor (see above);

(2) to determine the influence of manurial treatment on the subsequent storage behaviour.

Influence of Manurial Treatment.

Fruit for these experiments was obtained from the College Farm from a series of plots with different manurial treatments.

In the fruit from two plots, viz.: synthetic pen-manure and those to which in addition there was added 2 lbs. potash per stool, there appeared to be no difference, either in rapidity of ripening and senescence or in bruise resistance. In general it may be said that considering the initial unsuitability of this soil for banana growing, the parent plants have shown an amazing response to manurial treatment as indicated by vegetative vigour and size of bunch and fingers (5).

Almost without exception these bunches of rather turgid fruit have been very subject to bruising. This may be attributed to the rushed growth and perhaps to the long rainy season. Top hands have consistently shown mechanical damage despite the short journey to the Low Temperature Station, some 60 to 80 per cent. of the bunches being affected. From the several trials conducted it can only be concluded that fruit of this variety, grown with the help of fertilisers on relatively poor soils, is so subject to mechanical injury during transport that it is quite unsuitable for exporting as naked bulk consignments.

In general, bunches of the Governor variety from the College Farm ripened attractively within the usual time. The Governors from the Agricultural Experiment Station and from Woodford Lodge behaved much as did fruit from these localities in former trials.

Bunches obtained from the College Farm and from Maqueripe Estate consistently developed pitting disease (4) in storage, while those from the Agricultural Experiment Station and Woodford Lodge did not.

Fillbasket.

Several bunches of this variety were held at 53°F. for 16 days, then ripened at 70°F. Normally this fruit ripens attractively at ordinary temperatures. After the cold storage treatment, however, the colour intensity deepened, and the flesh had good texture and a pleasant flavour of its own. As this fruit, grown in the College variety plot, had been very carefully treated in its short journey to the Low Temperature Station, bruising was obviated. Judged by external appearance, these were quite the most attractive bunches, Gros Michel included, which we have had in the Low Temperature Station. The bunch habit and the very thin skin would, however, preclude rough treatment. It is thought that this variety might be given more attention during the tourist season, as the small fingers (Lady Finger type of banana) would make them a pleasing oddity. Unless quite mature, however, there is a danger that the pulp may appear too astringent for some palates.

Gros Michel.

Standard Gros Michel bunches, were obtained from the Sangre Grande district and transported to the Low Temperature Station by lorry; after being stowed in bulk for 16 to 21 days at 53° F., the fruit on transference to 70° F. ripened to a good appearance and, in the matter of bruising and scarring, was perfectly normal. As judged by commercial criteria, the principal defect consisted in the tendency of some bunches to irregular ripening. To what extent this unusual physiological behaviour is related to climatic or cultural conditions has yet to be determined. In other experiments it was ascertained that "heavy ¾-full" fruit was more subject to chilling than the standard English grade, namely, "¾-full".

The College Hybrids I.C. 1 and I.C. 2.

Nine bunches of the new hybrid known as I.C. 2, which is highly resistant or immune to Panama Disease, were reaped at approximately ¾-full from plots in the College grounds and held at 53° F. for 16 days. Bunches of the hybrid I.C. 1 were also stored for comparison.

All the I.C. 2 bunches were quite ripe before the eighth day in the ripening room at 70° F. Like the Gros Michel parent they acquired a good yellow colour and several independent tasters declared them to be good in texture and flavour and superior to the I.C. 1. Furthermore, this hybrid possesses the Gros Michel toughness of skin and resistance to mechanical injury and fungal wastage. On the other hand, the bunches so far obtained have been rather small and the

fingers short, thick and closely packed. As a result, fullness in fruit soon leads to distortion of the bunch habit so that additional mechanical injury may result. In general, the shape of the finger is more like the Giant Fig than the Gros Michel.

As these bunches were grown on indifferent soil, the results of this preliminary storage trial should not be regarded as affording a true indication of the commercial possibilities of this variety. Like the Jamaican hybrid, this fruit is chiefly defective in the shortness of the fingers and further storage trials should be based on fruit grown on good soil. It will be interesting to note to what extent characters commercially objectionable can be modified by agricultural treatment.

The I.C. 1 bunches, introduced as a standard of comparison, behaved in a manner which confirmed earlier storage trials (2).

The Giant Fig, Lacatan, Bumulan, Martaban and Masak Hijau Varieties.

The affinities of this interesting assemblage of varieties as determined by field and storage criteria have already been discussed in the columns of this Journal*.

Mycological Observations.

As in previous storage trials, fungal wastage was of the usual type, being chiefly associated with mechanically injured tissues. Main-stalk rot was satisfactorily controlled by the application of vaseline to freshly cut stem ends and by rapid cooling. Tip-rots, caused by *Gloeosporium musarum* Cke. & Massee and *Botryodiplodia theobromae* Pat. were again in evidence as maturity was being reached. In the characteristic mechanical injuries, Fig. 5, which developed in finger-stalks of the Giant Governor, the subsequent rotting could be referred to *Glomerella cingulata* and *Fusarium sambucinum*.

For the first time during our storage trials in Trinidad, Pitting Disease, which is responsible for considerable wastage in Brazilian cargoes (4), has made its appearance on the Cavendish, Giant Governor, Fig. 5, and Gros Michel varieties. It has again been shown that *Piricularia grisea* (Cke.) Sacc. is the principal associated organism. The latter and *Helminthosporium torulosum* are responsible for other spots distributed over the surface of fruits. Pitting disease and the question of fruit spotting will be dealt with in greater detail in a later report.

Conclusions and Recommendations.

1. The storage behaviour of the following varieties has been considered during recent investigations at the Low Temperature Station: Giant Governor, the Dwarf, Cavendish or Governor from various sources, Fillbasket, Gros Michel, the Hybrids I.C. 1 and I.C. 2, Giant Fig, Lacatan, Bumulan, Martaban and Masak Hijau.

2. The Giant Governor, believed to be a tall mutant of the Dwarf or Cavendish variety, in the course of four bulk storage trials has given promising results. When grown under similar conditions, this variety produces considerably larger bunches than the ordinary Dwarf or Governor variety, while the cylindrical shape and symmetry of the bunch and the relatively tough skin of individual fruits render it much more suitable for naked bulk transport. So far, the excessive injury to the top hands and general scarring, usually found on the ordinary Governor, have not been observed. Chill effects developed in fruit held at 53° F. for 16 or more days, but after cold storage at 58° F. normal ripening to an attractive deep yellow colour was the rule. A transport temperature commencing at 56° F. and rising to 58° F. would probably be suitable for this variety. Bunches must be reaped at a stage corresponding to "heavy ¾-full" in the Gros Michel, otherwise ripening at 70° F. is greatly delayed and abnormal colour effects, such as pastiness or russetting, develop. Fruit for export thus tends to be heavy and the individual fingers of rather large size. Texture and flavour are good. Shipping trials, conducted under the usual commercial conditions at a temperature of 56° to 58° F. are necessary before a definitive opinion can be offered.

3. The Cavendish or Governor variety when grown on relatively poor soil with the help of fertilisers showed a very marked response to the manurial treatments. The bunches, however, proved very subject to mechanical injury, damage to finger-stalks, bruising and scarring being excessive even after a very short careful haulage. Such fruit would be quite unsuitable for export.

4. Judged by their bunch habit, colouring, texture, flavour, &c., Dwarf Cavendish from various sources, British Guiana, Trinidad, Barbados, Virgin Islands and Canary Islands, &c., seem to be very closely related if not one and the same variety.

5. Bunches of Fillbasket held at 53° F. for 16 days subsequently ripened very attractively at 70° F. While its bunch habit and thin skin preclude rough treatment, it is thought that it might possess some local commercial value.

6. In two bulk storage trials with the Gros Michel, wastage due to breaking of finger-stalks, scarring and bruising, was quite normal and comparable with that experienced in Jamaican or Central American fruit. Uneven ripening in bunches, where single fingers or entire hands were involved, was a characteristic feature of both trials. As this would be regarded as a serious defect by the Trade, further investigations to determine whether it is cultural or seasonal are required.

7. In a preliminary storage trial with the new College Hybrid I.C. 2, it was found that this variety possesses characters common to the Gros Michel, namely resistance to bruising and attractive yellow colour on ripening. The flesh

* *Trop. Agriculture*, Vol. X, No. 8, 1933.

is of good texture and is regarded as being superior in flavour to the hybrid I.C. 1. The bunches so far obtained—on relatively poor soil—have been small and the fingers short, thick and closely packed. Further storage trials are required with well-developed bunches grown on good alluvial soil.

8. Bunches of Giant Fig, Lacatan, Bumulan, Martaban and Masak Hijau, of approximately the same age and obtained from the same or adjacent rows in the College variety plot, were stored and ripened under identical conditions. All showed very great similarity in the characters developed during ripening. This lends support to a view which has been expressed that these several tall forms are not separate and distinct varieties, but are, in fact, identical.

9. Pitting Disease, which is responsible for considerable wastage in Brazilian cargoes, was in evidence during these trials on the Giant Governor and Governor varieties. A very mild and economically unimportant form of this disease was also observed on the Gros Michel.

In conclusion the writers desire to acknowledge the assistance they have received in carrying out this work. To the Trinidad Department of Agriculture, Mr. G. F. Huggins, O.B.E., Mr. R. Huggins, Woodford Lodge Estates, Ltd., and the College Departments of Agriculture and Botany, they are indebted for supplies of fruit, and they again avail themselves of the opportunity of expressing their thanks to the Principal and Members of the Staff for their helpful co-operation.

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OBITUARY.

DR. L. P. McGUIRE.

It was with profound regret that members of the College Staff heard of the death of Dr. Laurence Patrick McGuire in London on 6th October.

As a young man in Natal, his birthplace, Dr. McGuire already showed much of the promise he was to fulfil later as a working biologist. His scholastic successes took him in turn to his home University, and to the Imperial College of Science and Technology, London, where he gained the higher degree of Doctor of Philosophy. In 1928 he was appointed as Physiologist, under the Banana Research Scheme, to the Imperial College of Tropical Agriculture, and with a colleague was jointly responsible for storage investigations at the Low Temperature Station.

With a sound training in plant physiology acquired at South Kensington and the practical outlook on refrigeration and storage problems gained at the Low Temperature Research Station, Cambridge—one of the few institutions of its kind in the world—McGuire came to the tropics with an equipment and point of view as unique as they were valuable. More than most working biologists, he possessed in a high degree the happy knack of combining science and practice both in his technical work and verbal exposition —an attitude of mind well suited to the exploration of the storage behaviour of perishable vegetable commodities and the proper application of scientific principles in handling large-scale consignments on land and sea. This is revealed in his published work, for he was a contributor to no less than six of the Empire Marketing Board's Grey Books which have received wide publicity.

In official life at the College, in an advisory capacity, he showed the same keen grasp of practical detail in its correct relation to the results of pure research. As an exponent of a branch of applied science yet in its infancy in the tropics, Dr. McGuire's early death cannot but be viewed as a serious loss. He was a man of much personal charm, humour and kindness. A keen sportsman, he excelled in many games which he pursued with characteristic zest, while socially it is not too much to say that he was invariably the life of the party and *persona grata* to all.

Members of the College Staff take this opportunity of expressing their high appreciation of Dr. McGuire's character and work and of the sympathy they bear for his family.

LABOUR AND LABOUR RATES ON THE COLLEGE FARM.

BY

R. C. WOOD, D. D. PATERSON and E. J. SEIGNORET.
The Imperial College of Tropical Agriculture.

I.—Introduction.

While the agricultural labourer in some capacity or other is found in practically every part of the world, the conditions under which he works and the emoluments he receives show considerable diversity. The contrast is particularly marked when farms in the temperate regions are compared with those in the tropics, and the latter really require separate consideration. Within the tropical zone itself, there is also great variation in the labour rates paid in different countries and even in different localities in the same country. On the other hand, there are certain general features which are more or less common to the equatorial belt as a whole. In this article, these common characteristics are discussed very briefly, and data extracted from the farm records of the College are quoted as they provide a fairly typical picture of the standards of payment expected by the field workers. It should be clearly understood that the figures given cannot be applied indiscriminately to other colonies or even to other estates in Trinidad. Provided the daily wage normally earned by the agricultural labourer in any locality is known, they should make it possible to form, for that locality, a rough estimate of the labour costs of many of the commoner cultural operations.

Keen competition and the existing depreciated value of agricultural produce have forced the farmer to give more thought to the economic organisation of his farm as distinct from the purely agricultural. Wages to hired labourers normally form the heaviest single item of expenditure in the running expenses, and it is in the reduction of his weekly labour bill to a minimum, without loss of efficiency, that the good farmer can most easily demonstrate his superiority over his less skilled or more careless confrère. By suitable modification of his farming system, he can ensure that there will be productive work for the whole of his labour staff during the greater part of the year. On any farm, there will always be sufficient odd jobs to keep all the men busy, but it is necessary to distinguish between productive or useful work and the semi-ornamental type that is performed in order to provide employment during the slack periods. At the same time, if the farm is going to yield a profit, it is essential to have the necessary number of workers to carry out the different field operations—ploughing, sowing, harvesting, &c., as near as possible to the optimum date; failure to do this only means that any saving effected in the weekly labour bill will be lost twice over in the reduction in yield or quality of the produce.

II.—Permanent and Casual Labour.

There are two main classes of labour, namely, Permanent and Casual. In England and other countries where farm labour is difficult to obtain, practically the whole of the staff will, of necessity, be of the permanent type. This throws on to the farmer the onus of arranging his cropping so as to distribute his field work evenly throughout the twelve months of the year. Such a distribution entails real foresight and skill, as the different crops make widely different demands in regard to the number of man-days per acre required. For example, potatoes will need perhaps 30 man-days per acre, while an average cereal crop will take only seven or eight. Effective organization is possible, however, by using early and late sown crops, short and long season varieties, by a suitable division of the rotation to cereals, roots, hay and pasture, and so on. The fluctuations in the weather will upset even the best thought-out system, but in a normal year, the forecast of the monthly labour requirement will be fairly accurate. There is, moreover, much to be said in favour of the permanent employee when compared with the casual; he is generally a better class of man, with a greater sense of responsibility, and with a genuine interest in his employer's welfare and in the prosperity of the farm. With the growth of Trade Unionism in rural districts, this is less true to-day than it was a couple of decades ago, when the farm labourer was renowned for his whole-hearted attachment to duty and to the farm from which he derived his living. Nevertheless, the permanent man is still generally the more skilled and more responsible individual, and this is particularly important under modern mechanised farming conditions, when a careless workman can do serious damage to valuable machinery in the course of a few seconds.

In contrast to this state of affairs, agricultural establishments in the tropics depend primarily on casual labour for the greater part of the field work. In the more backward regions, the share system may even predominate; under this system, the landowner or tribal chief supplies the land, the implements, the seed and the capital outlay in general, while the peasant is responsible for the whole of the cultivation. After harvest, the landlord receives a share of the produce from the cultivator; this share represents interest on capital outlay, rent for the land, and wear and tear on implements and machinery. The exact proportion he receives varies greatly from one locality to another and may be anything from 10-60 per cent. of the total crop; it is based

rather arbitrarily, and largely in accordance with custom, on the relative responsibilities of the two contracting parties. The whole system is an anachronism and, in conjunction with its boon companion, usury at impossible rates of interest, has probably done as much to hold back true agricultural progress in many countries as all the other retarding agencies combined. The adoption of hired labour in place of the old share system is an essential to all capitalised agricultural industries, and wherever new estates or plantations on any scale have been opened up, paid labour is the general rule. While this is composed largely of the casual labour class engaged and paid on a day-to-day basis, there is normally also, in addition to the senior office staff, a limited number of permanent employees attached to each estate; to this class belong usually overseers, gangers, foremen, drivers, as well as the men who work with livestock and machinery and have become skilled artisans in their own particular line. Where an assured and plentiful supply of casual labour can be obtained all the year round, the organization of the farm becomes a comparatively simple matter as it is possible to plan the farm work from day to day, and then engage the requisite number of labourers. In practice, however, it will normally be found that, in a given locality in the busy season of the year, the supply is not equal to the demand, and just when the farmer wants his largest staff of workmen they are also required on his neighbour's property; wages tend to go up through competition, and he may even be left with part of his crop unsown or unreaped. Furthermore, the casual workman feels he owes no allegiance to his employer who engages him only when extra hands are required, and dismisses him without warning or notice. These facts, combined with a comparatively low standard of education and mentality, are responsible for less skilled workmanship and considerable slacking whenever opportunity occurs. They have even necessitated the employment of foremen, gangers, &c., on relatively high wages, in order to assess the tasks or piece-work dues and to maintain the standard and rate of work at a reasonable level. Senior fieldmen of this type are to a large extent unnecessary under the less primitive conditions of the temperate regions.

There are, therefore, advantages and disadvantages under both the casual and the permanent system of labour employment. Probably the ideal farm from the management viewpoint is the one which is run with a limited number of responsible and skilled permanent employees and is situated in a locality where in any unforeseen rush period extra day-labourers can be engaged.

III.—Payment of Casual Labour.

Casual labour is normally paid on a daily wage basis either by time or by output, or, as it is sometimes expressed "by the bell or by the yard". The relative advantages and disadvantages of piece-work and time-work payment are too well known to need discussion here. The fixing of the time work rate is comparatively simple; it will depend first of all on supply and demand, and secondly on the standard daily payment expected by the average manual worker in the locality. In Trinidad, it may be taken that the average daily wage rate of an ordinary farm labourer is about 40 cents*. Many of the women also, seek employment on the land, and, in spite of the fact that, for certain tasks, female labour is both better and quicker, custom prevails over common-sense, and where a man is offered 40 cents, a woman will only be able to earn 30 cents. Children from the age of 12-15 years will be given 15-20 cents depending on their capabilities. Needless to say, near the large towns higher daily wages are usually expected, while in the country districts lower rates may suffice; in this latter case, the difficulty is not generally high wage demands, but paucity of population. The figures quoted hereafter for labour rates are all based on the standards of:—

40 cents	for a man	per working day	of 9 hours.
30	do.	woman	do.
20	do.	boy	do.

In localities where the normal wages are lower or higher, or the length of the working day is different, a proportional alteration must be made in the rates. The men are on duty from 7-12 a.m. and 1-5 p.m., making the 9-hour day specified above. In practice there is always a certain amount of time unavoidably utilised in allocating the tasks, distributing the implements, moving from one field to the next, and so on; of necessity, this is included in the 9 hours.

The adjustment of piece-work so as to be fair both to the employer and the labourer needs considerable judgment. One of the chief difficulties is that the work required to complete a given task varies over a wide range, with the season, the type of soil, the rainfall, the particular field, the thickness of the crop, and many other factors. There can be no hard and fast rule; while the overseer has average figures on which he can base his demands, he must use his own discretion and assess his piece-work rates according to the work involved. If he is too severe a taskmaster, he will only cause discontent among his men and skimping of the work; if he is too lenient, he will be looked on as easy game, and shirking and general lack of discipline will result. A trustworthy supervisor who has the confidence of both employer and men is invaluable in keeping the farm running on oiled wheels.

Payment on piece-work may be made either by (*a*) the unit of work done, or by (*b*) the task, a system which has found favour in Trinidad. Where the unit of work can be weighed, counted or otherwise measured quickly and accurately at the end of the day, the former is probably the better system as the greater the output, the

* The dollar in Trinidad is based on Sterling, $4.80 being the equivalent of the English pound, *i.e.*, 1 cent = 1 half-penny.

higher the wage. Where the estimation of the day's output is difficult, it is simpler and fairer to divide the work up into so many easily measured units or tasks at the beginning of the day, each unit being assessed on the amount of work that an average labourer should normally finish in a short working-day of 6-7 hours. For every task executed the worker receives a full day's wage, *i.e.*, 40 cents for a man and 30 cents for a woman. Payment is usually made only when the task is completed, but occasionally a half or even a quarter of a task may be allocated, as, for example, when a labourer has been employed for the first part of the day on other duties. In some cases good workers will finish a couple of tasks in a single day, but mostly the men are content to do one task and go home as soon as it is finished. It is not uncommon to see a man, who has been on task-work, returning home at 11 or 12 o'clock in the morning, having completed his unit and earned a full day's pay. Many of the labourers prefer this system as, if they put forth their full energies, they can frequently get through early and still be left with time for a short rest and the opportunity of doing a little cultivation in their own crops before sunset. It has another advantage in that there is not really the same incentive as on piece-work to skimp the quality. When working by task, if they hurry unduly, they merely save themselves ½-1 hour in time, get no extra payment, and run the risk of being accused of low grade work and of being asked to do the job over again. Comparison of the piece-work and task-work rates as a whole with the figures quoted for an average day's work by a man on time duty brings to light another interesting fact. On the average it will be found that the unit of work is higher in the former system than in the latter. The men on a fixed daily wage do not exert themselves unduly, though possibly the quality of the work may be better. It follows, therefore, that in the rush seasons the best incentive to get any operation put through quickly is to pay by the piece or the task and combine this with the necessary amount of supervision to ensure that the quality of the work does not suffer.

IV.—Labour Rates.

The figures quoted in the following lists have been obtained from the records of the College Farm and represent the experience gained by the Agricultural Department of the College during some six years of arable farming under Trinidad conditions. A very wide selection of tropical crops is grown on this farm in order to provide material for demonstration to students. In consequence, the figures given are for an unusual range of crops and of operations. From the cultural aspect, the soil is light and easy to work; it is of rather low fertility, and might be described as a loam containing a fair proportion of silt. As a result of its friable nature, manual and implemental cultural operations require considerably less energy output than on the heavy alluvial plains to the south, and this fact should be borne in mind in comparing these lists with others from outside localities. The field workers probably represent a fairly typical sample of the West Indian labouring class which is made up of an assortment of races varying from the pure East Indian to the full-blooded negro; the former will normally be found in the more skilled and more responsible posts. The implements used are mainly of English manufacture, being essentially of a type to which the West Indian is accustomed. It can be assumed, therefore, that they are of suitable construction for efficient workmanship. The rates are average figures intended to represent a fair estimate for tasks carried out under normal working conditions in the locality. The number of different items that could be included in such a list is practically endless, and selection has been limited to the common operations and to those which have passed the acid test of practical application. Furthermore, they have been classified under two heads, according to whether payment is normally made on a piece-work or a task basis.

A.—PIECE WORK RATES.

(*a*) *Crops.*

Crop.	Operation.	Quantity.	Cost in Trinidad cents.
Cotton ..	Picking American Upland or Sea Island varieties ..	Per lb. of seed-cotton ..	½
Maize ..	Picking and stripping cobs by hand*	Per 100 lb. cob ..	7
	Stripping cobs in barn*	Per 130 lb. cob (*i.e.* 1 barrel)	4
	Shelling cobs by hand-beating in sacks*	Per 100 lb. seed ..	8
Onions ..	Lifting and trimming from crop yielding 4-5 tons per acre	Per 100 lb.	1½
	Stringing in drying crib	Per 100 lb.	12

* Normally women's work.

A.—PIECE WORK RATES.—CONTINUED.

Crop.	Operation.	Quantity.	Cost in Trinidad Cents.
Pigeon-Peas	Picking ripe pods by hand	Per 2 lb. pods	1
Sugar-cane *	Cutting at harvest, including trashing and topping ..	Per 1 ton (1 cart) ..	15
	Loading employers' carts with cut cane and carting within a one mile radius	Per 1 ton	16
	Cutting, loading contractors' own carts, and carting 2-3 miles	Per 1 ton	90 †
	Forking out old cane stools (mixed varieties) ..	Per 100 stools	10‡
	Forking out old cane stools (Uba variety)	Per 100 stools	20‡
	Cleaning drains of trash, &c., after harvest.. ..	Per 100 ft. (linear) ..	12
	Ranging cane trash into alternate 5 ft. rows ..	Per 100 ft. (linear) ..	3
	Spreading cane trash after ranging	Per 100 ft. (linear) ..	1
Sweet potatoes	Lifting and gathering tubers from crop yielding 4-5 tons per acre and planted in ridges	Per 100 lb. tubers ..	10
Yams ..	Staking yams with bamboo stakes and crow-bar ..	Per 100 stakes	40

* Noble cane varieties: the harvesting of thin cane is usually more expensive.
† This figure is rather higher than that quoted from the large sugar estates using local contractors.
‡ Frequently paid by the day and not by the piece.

(*b*) *Miscellaneous Farm Operations.*

Operation.	Description.	Quantity.	Cost in Trinidad Cents.
Draining ..	Drains, 18 ins. by 18 ins. in cross section	Per 100 ft. (linear) ..	35
Digging ..	Holes for planting orchard crops:		
	2 ft. by 2 ft. by 2 ft.	Per hole	1*
	3 ft. by 3 ft. by 3 ft.	Per hole	4*
Manuring ..	Loading carts with farm yard manure from cattle pen in compacted condition	Per 1 ton (2½ carts) ..	15
	Loading carts with well-rotted friable farmyard manure	Per ton	10
	Spreading farmyard manure in field	Per ton	4

* This figure is for soft soil; on hard baked, stony soil or soil permeated with roots, the cost will be 50-100 per cent. higher.

B.—TASKS.

Operation.	Description.	Task.
Brushing or Mowing ..	Ground vegetation with hand cutlass:	
	(i) Long tangled grass or short bush	5,000 sq. ft.
	(ii) Green manure as Sunnhemp	7,000 sq. ft.
	(iii) Light cover crop or weed growth	10,000 sq. ft.
Forking	Forking and inverting soil to 8 ins. in depth:	
	(i) on hard ground	3,000 sq. ft.
	(ii) on soft or previously ploughed land	5,000 sq. ft.
Ridging	Ploughed land, 4 ft. ridges as for sweet potatoes ..	4,000 sq. ft. or 1,000 linear ft.
Weeding *	In plant cane crop, spaced 5 ft. by 4 ft.	4,000 sq. ft. or 800 linear ft.
	In ratoon crop, spaced 5 ft. by 4 ft.	5,000 sq. ft. or 1,000 linear ft.
	In maize or similar crop sown in 3 ft. drills and previously horse hoed	13,500 sq. ft. or 4,500 linear ft.
	In broadcast crop of ordinary cereals or legumes ..	4,500 sq. ft.
	In onion crop, planted 1 ft. by 3 ins.	600 sq. ft.

* Normally women's work, and paid for at the rate of 30 cents per task instead of the 40 cents allowed for men's tasks.

V.—The Day's Work.

The following list shows the work output that may be looked for under normal conditions from men engaged on a fixed daily wage. The figures are again average ones, and represent the results of several years' practical experience.

A.—MANURIAL WORK.

Operation.	Description.	Quantity completed in nine-hour day.
Forking	Forking and inverting soft soil to 8 ins. in depth ..	3,000 sq. ft.
Planting	*Rice*; seedlings supplied	1/12th acre.
	Sugar-cane: with prepared sets put singly, 4 ft. by 5 ft.:	
	(i) In soft soil	1,000 sets (.5 acre).
	(ii) with crow-bar in hard soil	600 sets.
Harvesting	*Cotton*; picking American Upland varieties	50 lb. seed cotton.
	Cotton; picking Asiatic varieties	30 lb. seed cotton.
	Groundnuts; 1 woman, pulling and collecting	60 lb. nuts.
	Maize; picking and stripping..	500 lb. cob.
	Sweet Potatoes; lifting and gathering from a 4-5 ton crop	400 lb. tubers.
	Yams; lifting and cleaning from a 10-12 ton crop ..	400 lb. tubers.
Threshing	*Cowpeas* or similar legume, in dry condition. Gang of 1 man, 5 women and 1 pair oxen will thresh and winnow	1,500 lb. seed.
	Rice; beating on slatted table. 1 man and 1 woman ..	1,000 lb. rice.

B.—ANIMAL-DRAWN IMPLEMENTS.

Unless otherwise stated, the draught animals used in the following operations are locally-bred Zebu oxen between 1,000 and 1,200 lb. live-weight. Their walking speed when at work is only 2-2½ m.p.h., as compared with about 3 m.p.h. obtained from mules. On the other hand, the oxen maintain a steady rate of work for the whole day while the mules tend to flag in the late afternoon.

Operation.	Description.	Quantity completed in nine-hour day.
Ploughing	*Victory* or similar small digger plough. 1 pair oxen. 6 ins. by 8 ins. furrow. In unploughed land ..	¾ acre.
	Cross ploughing or in soft soil	1 acre.
	Gallows or similar digger plough. 2 pairs oxen. 9 ins. by by 12 ins. furrow slice	¾ acre.
	Disc plough. 10 ins. by 12 ins. furrow slice	¾ acre.
Ridging	After preliminary furrowing with Victory plough and using *E. T.* or similar *Ridging* plough with 1 pair oxen to make 4 ft. ridges as for sweet potatoes	1½ acre.
Harrowing	*Disc* harrow with 8 discs and 4 ft. cut 1 pair oxen ..	4 acres.
	Spring-tooth harrow, with 14 tines, 5 ft. cut. 1 pair oxen	3 acres.
	Chain harrow, 4 ft. 6 ins. cut. 1 pair oxen	4 acres.
Rolling	*Cambridge* roller, 6 ft. wide, 12 cwt. size. 1 pair oxen ..	4 acres.
Intercultivation in 3 ft. rows	*Planet Junior* or similar horse hoe. 1 ox or mule. Single cultivation	3 acres.
	Straddle cultivator. 1 pair oxen. single cultivation, but with a certain amount of overlap	3 acres.
Manuring	Sowing artificials, up to 5 cwt. per acre, ready mixed and delivered at field, the *Ajax Manure Distributor*, with 7 ft. spread, being used. 1 pair oxen	6 acres.
Sowing	Using single drill *Pilot Planter*. 2 men and one mule. Drills 3 ft. apart.	3½ acres.

STUDIES IN WEST INDIAN SOILS.

The Soils of Jamaica.

THIS Report (1) deals with the results of a broad survey of the main agricultural soil types of Jamaica from the points of view of their origin, mode of formation and field relationships. It forms Part VI of a series entitled "Studies in West Indian Soils", the first two of which (dealing with the soils of Dominica and of Montserrat respectively) were published in 1920 in the now defunct *West Indian Bulletin*. The others of the series deal with the soils of Tobago (2), of Grenada (3) and of Antigua (4), and were issued during the years 1931, 1932 and 1933. Further contributions to our knowledge of West Indian soils are in course of preparation. The series is intended to form a basis for further detailed work along varied lines, and to furnish evidence from which it may be possible eventually to compare and contrast the soils of the Caribbean area, particularly from the aspects of pedology and world classification, of agricultural soil conditions and suitability to different crops.

The memoirs throughout attempt to stress the agricultural or practical bearing of soil studies, and the information they contain is based mainly on field and laboratory investigations of representative soil sections or profiles. Their preparation and publication forms part of the programme of work of the staff of the College Department of Chemistry and Soil Science under Professor F. Hardy, which is working in close co-operation with the officers of the College Advisory Department and of the Agricultural Departments in the various colonies whose soils are being severally investigated.

The memoir on the Soils of Jamaica recently issued was compiled by Professor Hardy and Mr. H. H. Croucher, Agricultural Chemist to the Jamaica Department of Agriculture, and is necessarily broad in scope, since no previous publication dealing exclusively with the soils of Jamaica has appeared. The agricultural lands of the island comprise both calcareous and non-calcareous soil types, owing to the nature of the parent rocks from which they were derived. Their development depends largely on the varied climatic conditions to which the products of rock weathering have been subjected—dry-region soils and wet-region soils being sharply differentiated. Further, flat-land soils may be differentiated from hill-land soils, the former being mainly irrigated alluvial types of great importance in the banana and the sugar-cane industries of Jamaica.

Some attempt is made to compare certain of the distinctive soil types of Jamaica with well-known world groups, several of which are also represented in other parts of the Caribbean area, such as Puerto Rico, Cuba and Antigua. Full details of fundamental physical and chemical soil constants, such as texture, reaction (acidity and alkalinity), content of organic matter and of nitrogen, carbon-nitrogen ratio, calcium carbonate content, available and potential plant nutrients, including phosphate and potash, and common salt content are presented and discussed for each layer of each soil profile; they represent the laboratory results of examination of some 466 soil samples, collected from 53 profiles selected by planters within areas typical of the chief agricultural districts of Jamaica. Three excellent maps, showing parishes, roads and rivers, rainfall distribution and geological features, are appended.

Although planters may not derive from this memoir the exact information they may need of the soils of their particular estates, it is hoped that the broad treatment of the subject may suggest possible adaptations and improvements, and may greatly aid in the choice of the sites and in the interpretation of results obtained both from field manurial experiments and detailed analyses of selected soil samples, which form a natural outcome of survey work of this nature.

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(1) Studies in West Indian Soils. (VI)—Some Soil Types of Jamaica, their Origin, Formation and Agricultural Relationships. By F. Hardy and H. H. Croucher. August, 1933. Price 2*s*.

(2) Studies in West Indian Soils. (III)—The Cacao Soils of Tobago. By F. Hardy, C. G. Akhurst and G. Griffith. February, 1931. Price 1*s*.

(3) Studies in West Indian Soils. (IV)—The Cacao Soils of Grenada, their Origin, Formation and Chief Characters. By F. Hardy, J. A. McDonald and G. Rodriguez. December, 1932. Price 1*s*.

(4) Studies in West Indian Soils. (V) — The Sugar-Cane Soils of Antigua. By F. Hardy, J. A. McDonald and G. Rodriguez. April, 1933. Price 1*s*.

Copies of the above may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

AGRICULTURAL NOTE BOOK.

Copies of Professor Wood's "Note-Book of Tropical Agriculture" (price 5 shillings) may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

EXPERIMENTATION AND APPLIED STATISTICS FOR THE PRACTICAL AGRICULTURIST.—*Concluded.*

BY

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XIII. Complex Experiments.

This is a term used here to define a field trial in which several widely contrasted factors such as spacing, cultural treatment, variety, manures, are being tested in a single large experiment. The advantages of such a method have been mentioned in Section VI. The number of combinations of different treatments is virtually infinity, and it is not possible to quote a general case which will be truly representative of all types. As regards the statistical analysis, each experiment will have to be considered separately: it is therefore absolutely essential to ascertain at the outset that the lay-out will permit of a valid statistical interpretation of the yield data. It is advisable to make a rough draft of the proposed statistical methods before the experiment reaches the field stage. When designing any such experiment, it is worth remembering that, if the treatment comparisons are well balanced, the data are both easier to analyse and also more likely to produce conclusive results.

To illustrate the items requiring consideration in the analysis of variance, the arithmetical calculations for two relatively simple experiments of the complex type are given in the succeeding pages. Current literature supplies many other examples of highly complicated experiments worked out by competent authorities.

Example XI.

A variety and manurial experiment with sugar cane in which two varieties of cane, X and Y, are tested in combination with two different types of manure at two rates of application. On a per acre basis, the manures consisted of 10 and 20 tons of farmyard manure and single and double dressings of a complete inorganic mixture made up of 4 cwt. sulphate of ammonia, 3 cwt. superphosphate, and 1½ cwts. of sulphate of potash. Chemical analysis of the farmyard manure showed that this mixture of inorganic fertilisers contained approximately the same total quantity of N, P_2O_5, and K_2O, as the corresponding dose of F.Y.M. All combinations of these main manures with each variety are included giving $2 \times 2 \times 2 = 8$ distinct treatments, as detailed below.

Treatment Type.	*Constituents.*
A	Variety X and 10 tons F.Y.M.
B	,, X ,, 20 tons F.Y.M.
C	,, X ,, single dressing of inorganics.
D	,, X ,, double dressing of inorganics.
E	,, Y ,, 10 tons F.Y.M.
F	,, Y ,, 20 tons F.Y.M.
G	,, Y ,, single dressing of inorganics.
H	,, Y ,, double dressing of inorganics.

The experiment was arranged on the randomised block lay-out, made up of the eight treatment types in two blocks, *i.e.*, 16 plots in all.

TABLE XIA.—YIELD DATA FOR PLANT CANE CROP IN TONS PER 1-30TH ACRE PLOT.

Blocks.	Treatment Types.							
	A	B	C	D	E	F	G	H
1	3.90	4.85	4.62	4.99	2.84	3.60	3.85	4.64
2	3.60	4.80	4.72	5.06	1.96	3.49	3.90	4.62
Grand Total=65.44								

In this experiment the yields as recorded consist of three figure digits, which makes the assumed mean method of working the quickest.

TABLE XIB.—DEVIATIONS OF YIELDS × 100 FROM AN ASSUMED MEAN OF 400, *i.e.*, PLOT YIELDS IN 1/100th TONS LESS 400.

Blocks.	Treatments.								Totals of Blocks.
	A	B	C	D	E	F	G	H	
	− +	− +	− +	− +	− +	− +	− +	− +	− +
1	10	85	62	99	116	40	15	64	129
2	40	80	72	106	204	51	10	62	15
Treatment Totals . . .	−50	+165	+134	+205	−320	−91	−25	+126	+144

Check. If the arithmetic is correct then,

Grand Total of Table XIA × 100

= Total No. of Plots × Assumed Mean + Grand Total of Table XIB.

$= 16 \times 400 + 144 = 6544$ (which tallies with the previous table). Ignoring for the present the various combinations of factors that go to make up each treatment type it is possible to use this Table of Deviations to analyse the data as an 8 × 2 randomised block lay-out as follows:

Grand Total of Table XIB = 144

Correction Factor $= \frac{144^2}{16} = 1296$

TABLE XIC.—TABLE OF SQUARES (FROM TABLE XIB).

Square of Plot Yields.	Square of Block Totals.	Square of Treatment Totals.
100	16,641	2,500
7,225	225	27,225
3,844	—	17,956
9,801	—	42,025
13,456	—	102,400
1,600	—	8,281
225	—	625
4,096	—	15,876
1,600	—	—
6,400	—	—
5,184	—	—
11,236	—	—
41,616	—	—
2,601	—	—
100	—	—
3,844	—	—
112,928	16,866	216,888
Total S.S. = 112,928 − 1296	S.S. Blocks $= \frac{16866}{8} - 1296$	S.S. Treatment $= \frac{216888}{2} - 1296$
= 111,632, having 15 degrees of freedom.	= 812, having 1 degree of freedom.	= 107,148, having 7 degrees of freedom.

Therefore Error S.S. = 111632 − (812 + 107148) having 15 − (1 + 7) degrees of freedom = 3672 with 7 degrees of freedom.

It is necessary now to split up the S.S. due to Treatment into its component parts. This is most easily done by making Tables for each pair of factors in turn, and working out the respective S.S. of each factor and the S.S. due to interaction between them.

TABLE XID.—VARIETY AND QUALITY OF MANURE.

Variety.	Quality. F. Y. M.	Quality. Inorganics.	Variety Totals.
X	A+B = +115	C+D = +339	+454
Y	E+F = −411	G+H = +101	−310
Manure Totals	−296	+440	+144

Variety S.S.

$$= \frac{454^2}{8} + \frac{310^2}{} - 1296 = 36481$$

with 1 degree of freedom.

Quality of Manure S.S.

$$\frac{296^2}{8} + \frac{440^2}{} - 1296 = 33856$$

with 1 degree of freedom.

Combined Quality × Variety S.S.

$$= \frac{115^2 + 339^2 + 411^2 + 101^2}{4} - 1296 = 75521$$

with 3 degrees of freedom.

Interaction S.S. Quality of Manure × Variety.

= 75521 − (36481 + 33856) = 5184 with 3 − (1 + 1) or 1 degree of freedom.

Alternative Method of Calculation.

Where an S.S. is dependent on only two totals, a quicker method of estimation is to square the difference between these totals (taking into account the signs) and divide by the total number of plots concerned.

Thus variety S.S.

$$= \frac{\{454 - (-310)\}^2}{16} = \frac{(764)^2}{16} = 36481 \text{ (as given above.)}$$

Similarly Quantity of Manure S.S.

$$= \frac{(440 + 296)^2}{16} = \frac{(736)^2}{16} = 33856.$$

The interaction can also be calculated directly by squaring the difference between the differences of the corresponding pairs of factors and dividing by the total number of plots.

Interaction S.S., Variety × Quality.

$$= \frac{\{(+115 - 339) - (-411 - 101)\}^2}{16} = \frac{288^2}{16} = 5184$$

This method provides an easy and quick means of checking the accuracy of the preceding calculations. It can also be extended to cases where three or more factors are involved, all combinations of the factors in pairs being taken in turn. The S.S. interaction will be the sum of the square of the difference between differences divided by the total number of plots concerned.

TABLE XIE.—VARIETY AND QUANTITY OF MANURE.

Variety.	Quantity of Manure. Single Dressing	Quantity of Manure. Double Dressing	Variety Totals.
X	A+C = + 84	B+D = +370	+454
Y	E+G = − 345	F+H = + 35	−310
Quantity Totals	−261	+405	+144

S.S. Variety (already calculated) = 36481.

S.S. Quantity of Manure.

$$= \frac{261^2 + 405^2}{8} - 1296 = 27722$$

with 1 degree of freedom.

Combined Quantity × Variety S.S.

$$= \frac{84^2 + 370^2 + 345^2 + 35^2}{4} - 1296 = 64755$$

with 3 degrees of freedom.

Interaction S.S., Variety × Quantity of Manure.

$= 64755 - (36481 + 27722) = 552$ with $3 - (1+1)$ or 1 degree of freedom.

Check.

$$\text{Interaction.} = \frac{\{(84 + 345) - (370 - 35)\}^2}{16} = 552.$$

TABLE XIF.—QUANTITY AND QUALITY OF MANURE.

Quantity.	Quality. F. Y. M.	Quality. Inorganics.	Quantity Totals.
Single Dressing	A+E = −370	C+ G=+109	−261
Double Dressing	B+F = + 74	D+H=+331	+405
Totals Quality	−296	+440	+144

S.S. Quality of Manure (already calculated) = 33856

S.S. Quantity of Manure (already calculated) = 27722

Combined Quantity × Quality S.S.

$$= \frac{370^2 + 109^2 + 74^2 + 331^2}{4} - 1296 = 64658$$

with 3 degrees of freedom.

Interactions S.S., Quantity × Quality.

$= 64658 - (33856 + 27722) = 3080$ with $3 - (1+1)$ or 1 degree of freedom.

Check.

$$\text{Interaction.} = \frac{\{(-370 - 109) - (74 - 331)\}^2}{16} = 3080$$

Finally there is the second order interaction *i.e.* the interaction between three factors, namely, variety, quality and quantity. This is the difference between the total treatment S.S. and the sum of the sums of squares for the other components.

2nd Order Interaction S.S., Variety × Quality × Quantity.

$= 107148 - (36481 + 33856 + 5184 + 27722 + 552 + 3080) = 273$ with the balance of the treatment degrees of freedom, namely 1.

TABLE XIG.—ANALYSIS OF VARIANCE.

Due to	S.S.	Degrees of Freedom.	Variance.	$\frac{1}{2}$ Log$_e$ of Variance ÷ 100*	Calculated Value of z.	Observed Value of z from Table of z (P=.05).
Total	111,632	15	—	—	—	—
Blocks	812	1	812	1.0471	.2180	.8606
Treatments :						
Variety	36,481	1	36,481	2.9497	2.1206	.8606
Quality of Manure	33,856	1	33,856	2.9124	2.0833	.8606
Quantity of Manure	27,722	1	27,722	2.8123	1.9832	.8606
Interactions :						
Variety × Quality of Manure	5,184	1	5,184	1.9741	1.1450	.8606
Variety × Quantity of Manure	552	1	552	.8542	.0251	.8606
Quantity × Quality of Manure	3,080	1	3,080	1.7137	.8846	.8606
Variety × Quality × Quantity of Manure	273	1	273	.5021	−.3270	.8606
Error	3,672	7	525	.8291	—	—

* The calculated value of z depends on the difference between logarithms, so that the reading of the logarithmic values can be simplified by moving the decimal point in the variances so many places to the left or right until the smallest variance lies between 1 and 10. In the above Table, $\frac{1}{2}$ Log$_e$ has been calculated from the variance divided by 100 and the smallest one becomes 2.73.

All the major treatments, variety, quality, quantity of manure show very distinct significance. Differences between eight plot totals greater than :

$$\frac{\sqrt{525 \times 8 \times 2 \times 2.365}}{100} = 2.17 \text{ tons are significant.}$$

The total yield of the eight plots of any Variety

$$= \frac{\text{Assumed Mean} \times 8 + \text{Variety Total from Table XI}_D}{100}$$

From Table XI$_D$, the total yield of all plots of Variety X

$$= \frac{400 \times 8 + 454}{100} = 36.54 \text{ tons.}$$

From Table XI$_D$, the total yield of all plots of Variety Y

$$= \frac{3200 - 310}{100} = 28.90 \text{ tons.}$$

Variety X is better than Variety Y.

Similarly it can be proved that the inorganic fertilisers are better than the F.Y.M. and that double dressings of manure are better than single dressings.

The z test also shows significance for the interaction between variety and quality of manure and a bare significance between quantity and quality.

The same combination of variety and type of manure or quantity and quality of manure is found on a total of only four plots.

The significant difference between such totals =

$$\frac{\sqrt{525 \times 4 \times 2 \times 2.365}}{100} = 1.53 \text{ tons.}$$

From Table XI$_D$, the Totals concerned are :—

Variety X with F.Y.M. $= \frac{400 \times 4 + 115}{100} = 17.15$ tons.

Variety X with Inorganics $= \frac{1600 + 339}{100} = 19.39$ tons.

Variety Y with F.Y.M. $= \frac{1600 - 411}{100} = 11.89$ tons.

Variety Y with Inorganics $= \frac{1600 + 101}{100} = 17.01$ tons.

This shows that the inorganic fertilisers are to be preferred to the F.Y.M. with either the X or Y varieties.

Similarly from the totals of quantity and quality of manure from Table XI$_F$, it can be proved that the single dressing of inorganic fertiliser has produced about the same yield increment as the double dressing of F.Y.M. and that the single dressing of F.Y.M. gives a significantly lower yield and the double dressing of inorganics a significantly higher yield than either.

On the other hand, the residual effect of the F.Y.M. is likely to be much greater than that of the inorganics. The following relative classification would be a fair one for the single crop under consideration :—

10 Tons F.Y.M. per Acre. Poor Yields.

20 Tons F.Y.M. or $8\frac{1}{2}$ cwt. of a complete artificial fertiliser containing :—

100 lb N.
54 lb. P_2O_5.
75 lb. K_2O Average Yields.

17 cwt. of a complete artificial containing :—

200 lb. N.
108 lb. P_2O_5.
150 lb. K_2O. High Yields.

Example XII.

In order to simplify the work in the field, it is sometimes advisable to lay out an experiment of the complex type, with one treatment series in main-plots and the second series in subplots within these main-plots. For example, with cultivation trials it is usually easier to work in a few relatively large plots than a number of scattered small plots ; or again, treatments that have to be harvested on different dates are much more accessible if a reasonably large area can be cut at one time.

The following experiment with Maize (*vide* Table XII$_A$) was designed to compare the effects of clean cultivation *versus* no post-sowing tillage, combined with three seedrates, namely 10, 20, and 30 lb. per acre. The cultural treatments were arranged in main-plots of $\frac{1}{10}$th of an acre in size. These main-plots were each subdivided to three $\frac{1}{30}$th acre subplots. Each of the three seedrates was represented on one subplot in every main-plot. The arrangement of these within the main-plot was a random one. The whole experiment consisted of two blocks in which the main-plot treatments were randomised.

The experiment is composed of a total of twelve plots. Using the Variable-squared Method of Calculation,

$$\text{The correction factor} = \frac{144^2}{12} = 1728$$

Working first of all with the main-plot units and ignoring subplot treatments, then :—

Total Main-plot S.S. =

$$\frac{42^2 + 41^2 + 29^2 + 32^2}{3} - 1728 = 42 \text{ with 3 degrees of freedom.}$$

Main-plot Treatment S.S. =

$$\frac{83^2 + 61^2}{6} - 1728 = 40.3 \text{ with 1 degree of freedom.}$$

$$\text{Block S.S.} = \frac{71^2 + 73^2}{6} - 1728 = 0.3 \text{ with 1 degree of freedom.}$$

Error (a) =

Total Main-plot S.S. − (Block S.S + Main-plot Treatment S.S.)

$= 42 - (40.3 + .3)$
$= 1.4$, with $3 - (1 + 1) = 1$ degree of freedom.

TABLE XIIA.—YIELDS OF MAIZE SEED IN KILOGRAMS PER PLOT.

Blocks.	Treatments.								Block Totals.
	Clean Cultivation.				No. post-sowing Tillage.				
	Seed Rate.			Main plot Totals.	Seed Rate.			Main plot Totals.	
	10 lb. per acre.	20 lb. per acre.	30 lb. per acre.		10 lb. per acre.	20 lb. per acre.	30 lb. per acre.		
1	12	15	15	42	8	11	10	29	71
2	11	16	14	41	9	12	11	32	73
Column Totals ..	23	31	29	83	17	23	21	61	144 Grand Total.

Seed Rate Totals 10 lb. per acre =40
20 do. =54
30 do. =50

Taking the Sub-plot units into consideration, Total S.S. =

$12^2+15^2+15^2+8^2+11^2....+9^2+12^2+11^2-1728=70$ with 11 degrees of freedom.

Total Treatment S.S. =

$$\frac{23^2+31^2+29^2+17^2+23^2+21^2}{2}-1728=67 \text{ with 5 degrees of freedom.}$$

Sub-plot Treatment S.S. =

$$\frac{40^2+54^2+50^2}{4}-1728=26 \text{ with 2 degrees of freedom.}$$

Interaction S.S., Sub-plot × Main-plot Treatment.

= Total Treatment S.S. − (Main-plot Treatment S.S. + Sub-plot Treatment S.S.)
$=67-(40.3+26)=.7$ with $5-(2+1)=2$ degrees of freedom.

TABLE XIIB.

Main Plots.	Sub-Plots.		
	10 lb. per acre.	20 lb. per acre.	30 lb. per acre.
Clean Cultivation ..	23	31	29
No. Post-sowing Cultivation ..	17	23	21

Arithmetical Check.

Interaction S.S. (*vide* Table XIIB) =

$$\frac{\{(23-17)-(31-23)\}^2}{12}+\frac{\{(31-23)-(29-21)\}^2}{12}+\frac{\{(23-17)-(29-21)\}^2}{12}=\frac{(-2)^2+0^2+(-2)^2}{12}=\frac{8}{12}=.7 \text{ (as worked out originally).}$$

Error (*b*) = Total S.S. − (Block S.S. + Total Treatment S.S. + Error (*a*)) = 70 − (0.3 + 67 + 1.4) = 1.3 with 11 − (1 + 5 + 1) = 4 degrees of freedom.

It should be noted that in estimating the sub-plot treatment effect, allowance is made for the interaction between sub-plot and main-plot treatments, but otherwise the calculation of Error (*b*) is exactly equivalent to that for a simple randomised block lay-out in which the blocks consist of the groups of three sub-plots in a main-plot. Thus, Error (*b*) Total S.S. − (Total Main-plot S.S., *i.e.*, small Block S.S. + Sub-plot Treatment S.S. + Interaction S.S.)

TABLE XIIc.—ANALYSIS OF VARIANCE.

Due to	Sum of Squares.	Degrees of Freedom.	Variance.	$\frac{1}{2}$ Log$_e$ of Variance × 10.	Calculated Value of z.	Observed Value of z from Table of z (P=.05.)
Total for Main-plots	42.0	3	—	—	—	—
Main-plot Treatments ..	40.3	1	40.30	2.9995	1.6800	2.5421
Blocks	0.3	1	.30	.5493	— .7702	2.5421
Error (a)	1.4	1	1.40	1.3195	—	—
Total for Sub-plots	70.0	11	—	—	—	—
Sub-plot Treatment	26.0	2	13.00	2.4338	1.8369	.9690
Interaction Sub-plot × Main-plot Treatment	0.7	2	.35	.6264	.0295	.9690
Error (b)	1.3	4	.33	.5969	—	—

The number of replications of the sub-plot treatments is much higher than in the case of the main-plot series, and in consequence, an experiment of this design is likely to give more conclusive results from comparisons of sub-plot treatments as distinct from main-plot treatments. It follows, therefore, that in this type of lay-out, the important series should be relegated to the sub-plot units: or alternately, factors in which large treatment differences are expected should be allocated to main-plots, while those in which the differences are likely to be small will be most likely to yield positive results if randomised over the sub-plots.

By comparison, the complete randomisation of treatment types as described in Example XI will give the most conclusive results with the series that has the smallest number of factors. For example, if two varieties and three kinds of manure are being tested in a single experiment there will be $3 \times 2 = 6$ plots in each block of which there will be three replications of any one variety but only two replications of any one manure.

Error (*a*) should be used to determine the significance of the block and main-plot treatment variances, while error (*b*) applies to those for the sub-plot treatment and interaction factors. The z test proves that the only significant variance is that for sub-plot treatment. The main-plot treatment variance compared with Error (*a*) is relatively large, yet no significance exists. The reason for this is the faulty design of an experiment in which the treatment and error variances are based on only a single degree of freedom. The differences between the main-plot treatment totals are considerable, yet the small number of replications used makes it impossible to prove that this difference is not purely a chance one. A difference between sub-plot treatment totals greater than $\sqrt{.33 \times 4 \times 2 \times 2.78} = 4.5$ kgs. is significant.

Sub-plot treatment totals are :—

For a seed rate of 10 lb. per acre—40 kilos.
do. 20 do. —54 do.
do. 30 do. —50 do.

The light seedrate of 10 lb. per acre has lowered very decidedly the yielding capacity of the Maize, but there is no advantage to be gained by increasing the seedrate from 20 to 30 lb. per acre.

These two elementary examples of the "complex" type of experiment should serve to illustrate the way in which this complexity widens the scope of the conclusions, but, at the same time, entails more skilled and careful planning at the outset. As with the earlier examples cited, they are only of limited application. Experience alone will enable the research worker to design such experiments efficiently and extract from them the fullest information. In conclusion, therefore, the novice is strongly advised to commence with relatively simple field trials until familiarity with both the cultural difficulties and the laboratory technique have provided the necessary experience to allow him to utilise, with confidence, more ambitious systems of experimentation.

Acknowledgments.

In compiling this article, the writer has had frequent recourse to the relevant literature. To the numerous authors, both of theoretical and practical memoirs, from whose work information has been drawn, he wishes to express his deep indebtedness.

The list of references has been limited to a few of the more modern books and articles which should prove helpful to those with little previous experience of statistics or of field practice. A fuller bibliography will be found in any of the standard works on the subject.

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STRIPE DISEASE OF MAIZE.

By R. E. D. Baker, B.A.
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Nature of the Disease.

Since the discovery of this disease it has been assumed that it is of a virus nature, but no definite proof of this has yet been brought forward. That the disease is transmissible by the insect *Peregrinus maidis*, Ashm. has been demonstrated in Cuba (4), Trinidad (1), and Tanganyika (5), but this does not remove the possibility that the disease is due to a stigmonose effect comparable with that produced on sugar-cane by the froghopper, *Tomaspis saccharina*, Dist. Attempts to transmit Stripe disease mechanically (3) have proved unsuccessful.

Experiments designed to show whether the disease was due to a virus or to a stigmonose were therefore devised. The experiments were based on the following assumption: if the disease is due to a virus it will be systemic and all leaves produced after infection will show the symptoms; if, on the other hand, it is a stigmonose, recovery and the production of healthy leaves will be possible provided that the insects are removed and excluded. Plants showing the disease in the field were therefore transplanted into kerosene tins and removed to the laboratory where they were carefully freed of all insects and kept under observation. Considerable difficulty was experienced in transplanting the diseased plants, but this was finally accomplished by lifting the plants in large masses of earth straight into the kerosene tins in the field.

The plants were examined for insects every day throughout the experiment but none were found. Healthy maize plants transplanted at the same time as the diseased ones were kept as a control. No difficulty was experienced in transplanting the healthy plants which remained so till the end of the experiment when they were growing rapidly.

Most of the diseased plants died after about ten days, but one continued to grow and produced new leaves showing obvious symptoms of Stripe disease. This result, together with the fact that the recovery of diseased plants in the field has never been observed may be accepted as proof that the disease is due to a virus and not to a stigmonose.

Distribution of Stripe Disease.

On a recent visit paid by the writer to St. Vincent, St. Lucia and Barbados, Stripe disease was found quite frequently in the peasant maize cultivations. Maize is only grown by the peasants in small plots in these islands, and the scattered distribution of these plots possibly explains why Stripe disease causes but little damage to the crop.

As far as is known at present the distribution of Stripe disease includes Cuba (4), Trinidad (1), St. Vincent, St. Lucia, and Barbados in the West Indies; Tanganyika (5); and possibly also Hawaii (2) and the Philippine Islands (6).

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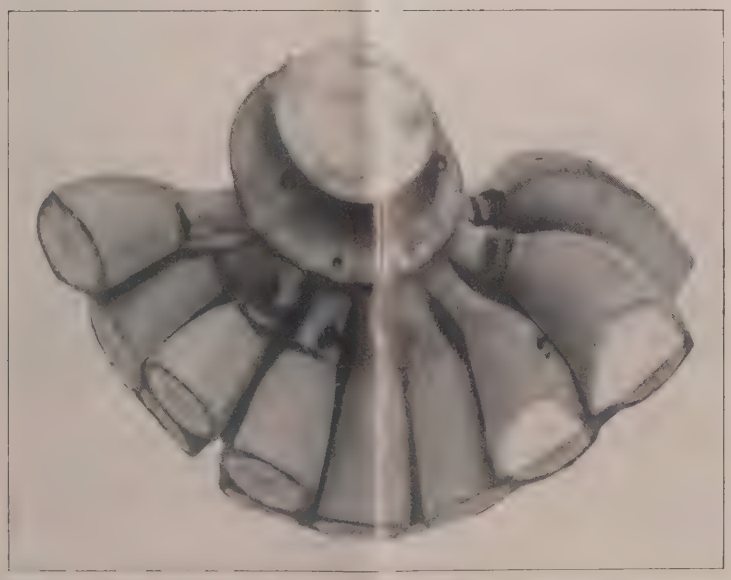
DISINTEGRATING ACTION OF ROOTS OF TREES.

In *Current Science* (Vol. I, No. 3, 78, Sept. 1932) a brief account was published of the work of Mr. Mohammad A. R. Khan, principal of Osmania University College, on the "Disintegration of Igneous Rocks due to the Action of the Roots of Certain Rock-loving Plants", the observations having been made in the Deccan. The species more specifically referred to were *Carissa carandus*, *Gymnosporia montana*, *Butea frondosa* and *Anona squamosa*. A communication to *Nature* (Vol. CXXXI, June 10th, 1933, p. 844) reports further investigations of this phenomenon. Mr. Khan attributes the extraordinary positions taken by the fantastically rounded igneous rocks of the Deccan in large part to the action of the roots of certain trees. Amongst these he considers that *Gymnosporia montana*, which is found for hundreds of miles in the rocky districts round about the City of Hyderabad, is the most formidable rock-disintegrator. It is well known that the roots of plants and trees exert an enormous influence in breaking up rocky strata beneath the surface of the superimposed soil layers; and that this is accomplished by the finer rootlets penetrating into tiny crevices and, through their subsequent growth in diameter, disintegrating the previously homogeneous mass. It is perhaps not so commonly appreciated that this action proceeds at a much more rapid pace in tropical countries, owing to the greater heat and moisture conditions. But Mr. Khan's observations would appear to show that the vegetation and the masses of smaller rootlets, which form a kind of lacework over the bases of the individual rock pieces of the curious Deccan formation, play a larger part in the disintegration and break up of the surface rocks than may have been so far attributed to it. "Where", he says, "the rocks are in contact with the soil (already formed) and the fine root-hairs of these plants have reached them, they (the root-hairs) enter the cracks and gradually draw upon the felspars and ferro-magnesium silicates for food . . . These root-hairs spread over the rocks and permeate into the rocky material far and wide . . . producing a specific disintegration".—(*Nature*, Vol. CXXXI, No. 3319. 10th June, 1933. p. 844.)

BANANA STORAGE.

Tucker Picture Co.

FIG. 4.—*Top and second hands of the Giant Governor, illustrating the tendency of fingers to fall apart when bunches are held with the proximal hand uppermost.*



Tucker Picture Co.

FIG. 5.—*Mechanical notching of finger-stalks and pitting disease in the Giant Governor.*

PROFESSOR H. A. BALLOU, C.B.E., M.SC.

AN APPRECIATION—PROFESSOR H. A. BALLOU.

THE British West Indies and the College have sustained a signal loss through the recent retirement from active service of Professor H. A. Ballou, Commissioner of Agriculture and head of the College Department of Zoology and Entomology since its inception in 1922. Professor Ballou was born in New Hampshire, U.S.A., in 1872, and received his early training at the Massachusetts Agricultural College during the period 1891 to 1895. After graduating, he served as entomologist in the gypsy moth campaign, and later as schoolmaster. In 1897 he became instructor in entomology and botany at the Connecticut Agricultural College, but returned in 1901 to the Massachusetts Agricultural College to undertake post-graduate studies in entomology. In 1903, at the recommendation of his teacher, Dr. H. T. Fernald, he was appointed entomologist in succession to Dr. Maxwell Lefroy on the staff of the Imperial Department of Agriculture in the British West Indies, with headquarters at Barbados. In 1906, he returned for a short period to Massachusetts in order to take his M.Sc. degree, awarded to him for a thesis on Cotton Stainers. During his period of service in the Imperial Department of Agriculture, Professor Ballou was seconded by the Secretary of State for the Colonies at the request of the Egyptian Government to advise on the control of the pink boll-worm of cotton, whose depredations were causing serious losses to the Egyption cotton crop. For his work in Egypt during 1916 and 1917, the grade of Commander of the Order of the Nile was conferred on Professor Ballou by the Sultan of Egypt. When the Imperial Department of Agriculture became merged with the West Indian Agricultural College in 1922, and shifted its headquarters to Trinidad, Professor Ballou became head of the entomological section, and eventually, in 1927, Commissioner of Agriculture, posts which he held when the status of the College was changed to that of the Imperial College of Tropical Agriculture, and subsequently to the date of his retirement in October of the present year. Thus, Professor Ballou has been actively engaged in entomological work for some thirty-eight years, thirty of which were spent specifically in studying agricultural conditions in the British West Indies. He has been associated in this work with many distinguished men of science, particularly Sir Daniel Morris and Sir Francis Watts (both previous Imperial Commissioners), Mr. F. A. Stockdale, Mr. Lewton Brain, Mr. R. D. Anstead, Mr. W. Nowell and Mr. S. F. Ashby, all former colleagues in the Imperial Department in Barbados.

It is difficult adequately to assess the beneficial effects which Professor Ballou's service to agriculture in the West Indies has conferred. Most of his time was spent in advisory work, in which his extensive and sound knowledge of local conditions rendered him eminently adapted. His published records mainly took the form of personal correspondence, and of numerous notes, reports and articles that were issued in the West Indian Bulletin, the Agricultural News, and the Pamphlet Series of the Imperial Department. He wrote a booklet in 1912, entitled "*The Insect Pests of the Lesser Antilles*", which has brought him considerable reputation. The greatest and most lasting benefits that he has conferred on West Indies agriculture, however, are due to his personal contacts with planters, agricultural officers and college students, all of whom have learnt to trust and to act on his sound advice. In fact, the chief feature of Professor Ballou's success as an agricultural scientist, lay in the confidence he invariably inspired in all who were associated with him, and the ever-willing help that he was able to give to those who put their problems before him. His characteristic approachableness, his friendly and attractive personality, his patience, tact and never-failing good humour, have endeared him to all who know him. His advice was sought by every class of administrator, business man and agriculturist, both estate manager and humble peasant alike. His wide store of practical knowledge, concerning most phases of West Indian agriculture, was an invaluable asset to the institutes with which he was variously connected, and it is indeed reassuring to feel that his unrivalled experience will still be available to many, although his professional associations have been relinquished. In view of these facts, it was indeed pleasing to his many friends to learn that His Majesty the King graciously bestowed on Professor Ballou the Order of Commander of the British Empire among the Birthday Honours awards of the present year. The best wishes of Professor Ballou's colleagues at the College go with him in his retirement, and all his friends hope that he will enjoy the very best of health and much happiness in the many remaining years of active life that are still before him.

REVIEW.

THE KIND OF CACAO THE MANUFACTURER WANTS.

By A. W. Knapp assisted by E. Wiehr and Léon Olivier; published in the "*Bulletin Officiel,*" *Office International des Fabricants de Chocolat et de Cacao.*" July, 1933.

This paper aims to describe the type of cacao which is most required by the manufacturer in general. Pure Criollo should not be grown except where it is likely to do well. For general planting an improved Forastero strain should be used. The desirable characters of cacao beans are briefly explained as well as the general defects. The defectiveness may be due in part to the bad practice of gathering unripe and over-ripe pods. Fermentation must be carefully carried out in order that it may be adequate but not excessive. Washing and claying are practices which should be abandoned. More attention must be paid to cleaning and bags should be used not more than once. It is essential that the beans should be kept dry during storage and transport and the turnout should consist of as uniform a product as possible.

F. J. P.

SUGAR NOTES.

Compiled by the College Department of Sugar Technology.

Horne's Method of Clarifying Raw Sugars for Polarimetric Examination. *P. Honig and A. Rooseboom.*

At the last session of the International Commission for Uniform Methods of Sugar Analysis the use of Horne's dry lead acetate as clarifying agent in the determination of the polarization of raw sugars was declared permissible (1). It was, however, recommended by a sub-committee appointed to further examine the matter that the difference between the two methods of clarification (the old so-called "wet method" and Horne's "dry method") should be investigated in different countries. This paper is a contribution studying the difference in the case of Java raw sugars.

Horne's dry lead acetate must be added after completing to volume, the error arising from the precipitate formed in the use of basic lead acetate solution thus being eliminated. Any excess of the solid reagent must be avoided as with the solution. Preferably first one should find how much of the basic lead acetate solution is necessary, and from this the quantity of solid reagent can be judged, assuming that 1 c.c. of solution equals 0.3 grm. of solid. Polarizations obtained by Horne's method should always be somewhat lower than those by the older method.

American and German dry lead acetates were used, analyses of these two makes being as follows:—normal lead acetate, 71.03 and 64.45; and free lead oxide (PbO) 26.89 and 31.47 per cent. So the German acetate was somewhat more basic than the American.

In the table below are given the average figures for the comparative polarizations by the two different methods, the sugar used being so-called *Nieuw Assortiment* requiring 1 c.c. of solution (with sometimes about three drops of aluminium hydroxide to give a bright filtrate) and 0.3 grm. of solid. It will be noticed that with the German preparation a somewhat smaller polarimetric difference occurs than with the American. Probably this can be ascribed to the somewhat higher alkalinity of the German reagent, which would have a rather greater effect on the levo-rotary compounds present in the sugar, thus giving a higher pol.

	American b.l.a.	*German b.l.a.*
No. of pols. made in all ..	96	22
Average pol. for the wet method ..	96.838	96.884
Average pol. for the dry method ..	96.758	96.825
Average difference	0.080	0.059

Recently in a paper by Zerban and Gamble (2) the same subject was treated. They used Cuban 96° raw sugar, solutions of which were first made sufficiently light in colour by treatment with decolorizing carbon; then polarized: (*a*) without any clarification; (*b*) after clarification with basic lead acetate solution; and (*c*) after clarification with dry basic lead acetate. Two series of 12 sugars were examined, the quantities of reagents used being 1 c.c. and 0.3 grm. in one series, and double these amounts in the other. Following are the average differences:—

	1 c.c. or 0.3 grm.	2 c.c. or 0.6 grm.
Wet method	+0.274	+0.306
Dry method	+0.168	+0.135
Average difference	0.106	0.171

Therefore omitting the figures for the double dose of clarifier (which was found to be in excess), an average difference of 0.106 was found for these sugars, a difference due to the error arising from the lead precipitate in the older method of clarification; the error caused by the remaining effect of the dry lead on the precipitation of levo-rotary compounds or by changes in rotation being thus 0.168. That the average difference with these Cuban sugars is greater than with the Javan N.A. sugars is due no doubt, the authors remark, to the Java sugars being purer, so that less precipitate was formed. In fact, in a series of 48 *hoofdsuikers* examined by them later, the average figure for the wet method was 98.448 and for the dry 98.472, a difference which is extremely small, and really negligible.

Their conclusion after considering all these results is that Horne's method is to be preferred; but that if the old method is still used, a correction must (excepting for high testing sugars) be applied for the volume error. In the case of the N.A. sugars examined by them, this correction would be about 0.07°V or, as a round figure, say 0.1°. —(*Inter. Sugar Journ.*, Vol. XXXV, No. 417. September, 1933, p. 358.)

(1) *Inter. Sugar Journ.*, 1933, p. 62.
(2) *Facts about Sugar*, 1933, XXVIII, No. 4, pp. 180-182.

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Sweetening-off the Filter Presses. *H. A. Schlosser.*

Where ample filter capacity is available the most satisfactory method of attaining a low percentage of sugar in the filter-press cake with minimum consumption of wash-water is low filtering (1½ hours per press), with separation of the rich from the lean sweet-water, the latter being used for the first washing of the next press. This separation of the sweet-waters is effected automatically in a very satisfactory manner by the apparatus invented by Hannicka.

Where filter capacity is limited and filtration must be effected in short cycles there is a tendency for the cake to crack, making it difficult to reduce the sugar content of the cake to a sufficiently low figure. Under these circumstances it is advisable to use the recently patented Stanek method, which consists in following the juice with a suspension of filter-mud in water or dilute sweet-water; this stops up the cracks and permits a more thorough washing. By either of these means it is possible to reduce the sugar content of the press-cakes below 0.5 per cent. (minimum 2 per cent.).—(*Inter. Sugar Journ.* Vol. XXXV, No. 418, 1933.)

CHEMICAL NOTES.

Compiled by the College Department of Chemistry and Soil Science.

Tea Cider.

A Circular issued by the Tea Expert Bureau, Java, describes a fermented beverage prepared from tea which seems to be very popular in the Dutch East Indies.

The Tea Cider is prepared by inoculating a tea infusion containing about 10 per cent. of added sugar with a small amount of 'tea fungus.' The latter has been known for a good many years, having been introduced into Germany from Russia about 1911. Its origin is unknown but was probably some eastern country. The 'fungus' is actually a mixture of a kind of yeast and a bacterium and develops rapidly in a tea infusion prepared as above and kept at a suitable temperature—25 to 38°C. If the fermentation is stopped at the proper time the resulting liquid forms a pleasant beverage closely resembling cider. If, on the other hand, the fermentation is prolonged, vinegar is produced, and it has also been used for this purpose in Java. In addition to its properties as a beverage, Tea Cider is claimed to possess certain medicinal qualities, having been found useful in cases of rheumatism and arterio-sclerosis. (*The Tea Quarterly*, Vol. V, Part III, August, 1932, p. 80.)

* * *

Investigations on Timber.

Under the auspices of the Department of Scientific and Industrial Research, the report of the Forest Products Research Board for the Year 1931 has been issued. It is combined with the report of the Director of Forest Products Research for the same year.

The investigations carried on during the year fall roughly into three groups: (*i*) the dry rot investigations being carried out in the new experimental building erected for the study of this subject, (*ii*) investigations into the death-watch beetle and into the damage caused by the *Lyctus* powder-post beetles, and (*iii*) investigation work on Empire timbers, more especially in the tropical hardwoods. Under (*iii*), the report of the Research Board has some pertinent remarks on the subject of encouraging and organising the placing of Empire tropical timbers on the markets. Several of the points discussed have been already alluded to in *Nature* (CXXIX, 696, 7th May, 1932).

The report describes improvements in the design of seasoning kilns, new apparatus for the determination of humidity in the kilns, and a method of employing the photo-electric cell in the study of wood structure by using it to measure the percentage of empty space in the interstices of a timber due to its cell structure. Apparatus is also described which determines the gloss of a machined surface by measuring the amount of light scattered or reflected from it. Another instrument measures the finish on a surface by recording the frictional resistance experienced by dragging a standard metal plate over the surface.

The report emphasises the importance of research on wood-working tools. "A new Empire timber is often condemned by the machinist as 'unworkable' simply because machines, developed to deal with timbers in common use, are not suited to the very different structure of the new timber. A modification of feed speed, cutting speed or cutting angle may be all that is necessary to make the most obdurate timber workable, but in order to foretell these modifications a knowledge of the way in which the cutting action of any tool, whether place, saw or drill, should be related to the structure of the wood on which it is to work is essential."

During the year, 689 specimens of structural timber were tested, while 3,470 test pieces cut from a material free from knots, &c., were submitted to almost every conceivable mechanical test. Test on physical properties, &c., numbered more than 9,500. A total of 4,800 specimens treated in various ways with eight wood preservatives, including low temperature tar and its distillates, have been exposed for test and are kept under constant observation. — (*Nature*, Vol. CXXXI, No. 3319. 10th June, 1933. p. 847.)

* * *

Reaction of Soils upon Animals.

The possible influences of the chemical conditions of soils upon the creatures which exist upon them have not been fully realised, and Dr. Stewart MacLagan has studied the relationship in a series of selected types (*Proc. Roy. Physical Soc.*, Edinburgh, XXII, 107; 1933). Indirectly, even vertebrates may be affected by the composition of the soil, since acid content is reflected in the composition of the herbage and this may be expressed in calcium deficiency, as in the 'bent-leg' disease of sheep. Earthworms and snails are most numerous in soils which are approximately neutral in reaction, and a series of experiments with the primitive insect (Collembola) *Smynthurus viridis*, showed that soil reactions appreciably influenced the duration of the reproductive phase, and profoundly influenced the reproductive capacity of the insect. Since Collembola, like earthworms, swallow soil, it is suggested, from morphological and physiological evidence, that they also may have the power of modifying the 'acidity' of the soil, so that they gradually create a more favourable environment for their own existence. (*Nature*, Vol. CXXXII, No. 3332. September 9th, 1933, p. 412.)

TREND OF THE MARKETS.

[*The notes below are based principally upon running charts of the prices of the basic grades and upon general statistical information gleaned from contemporary publications and cablegrams and are intended to be a record of movements. An attempt is made, where possible, to indicate the market outlook at the time of going to press, but no responsibility for the accuracy and subsequent truth of such observations is assumed. Unless otherwise stated the prices quoted are spot, London.*]

SUGAR.—Prices on the Home Market have ranged as follows (c.i.f. per cwt.) :—

	Foreign.	*Preferential.*
	s. d.	*s. d.*
28th September ..	5 0¾	9 9¾
5th October ..	4 11¼	9 9¾
12th October ..	4 11¼	9 10½
19th October ..	5 0¾	9 7½
26th October ..	5 0¾	9 9¾
2nd November ..	4 11¼	9 9
9th November ..	5 1½	9 6
(*10th Nov.*, 1932)..	5 10½	10 7½

The further liquidation of early positions and the weakness of the New York market arising out of the abandonment of the Marketing Agreement in U.S.A., coupled with the continued uncertainty as to the turn of events in Cuba, has resulted in an easier tone. According to *C. Czarnikow Ltd.* the further recession of sugar values in New York appears, however, to have been primarily influenced by the decline in most other commodities which followed the report of the Treasury's Federal Conversion Scheme. Licht's estimates of European production show a decrease of 169,000 on Dr. Mikusch's estimates issued in August. The statistical position of sugar is gradually heading towards a more even balance although at the moment the adjustment is only proceeding from the production end, consumption being still held in check by the prevailing economic depression.

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COFFEE.—Latest prices realized include Kenya 47*s.*, 60*s.*, 70*s.* 6*d.*, 78*s.*; Costa Rica 52*s.*, 60*s.*, 152*s.*; Santos 42*s.* 6*d.*

* * *

RUBBER.—Quotations for Plantation Sheet have ranged as follows :—

	d.
27th September	$3\frac{29}{32}$
4th October	4
11th October	$4\frac{1}{32}$
18th October	$3\frac{27}{32}$
25th October	$3\frac{7}{8}$
1st November	$3\frac{29}{32}$
8th November	$3\frac{31}{32}$
(*9th Nov.*, 1932)	$2\frac{5}{8}$

In the absence of any progress regarding restriction, the rubber market has been quiet. The American *Questionnaire* consumption figures for September show a considerable reduction on those for August. Total consumption in the U.S.A. for the first nine months of the year is, however, 313,112 tons as against 252,203 tons for the same period last year.

COCOA.—On account of violent exchange fluctuations the cocoa market remains very uncertain. Prices if anything are slightly steadier and recent quotations on various grades are as follows :—Accra 21*s.* 6*d.* to 23*s.*, Superior Bahia 21*s.* 3*d.* per 50 kilos cost and freight, fine San Thome 26*s.* per cwt. c.i.f. and locally $4.70 to $4.80 per fanega for plantation cocoa".—(*By courtesy of The Cocoa Planters' Association of Trinidad Limited.*)

* * *

COTTON.—The following are the official spot prices in pence per lb. of the Liverpool Cotton Association :—

	American Mid.	*Egyptian F.G.F. Sakel.*
29th September ..	5.60	7.39
6th October ..	5.44	7.22
13th October ..	5.44	7.16
20th October ..	5.48	7.05
27th October ..	5.54	—
3rd November ..	5.46	—
10th November ..	5.36	—
(*11th Nov.*, 1932) ..	5.60	7.99

Prices have generally shown little fluctuation. The Bureau Report's figures at 12,885,000 bales was about 300,000 bales larger than generally expected.

Sea Island Cotton.—During the past fortnight there has been a limited enquiry for West Indian Sea Island Cotton and a few lots of Barbados and St. Vincent have been sold at 14*d.*, New Crop Extra Fine Montserrat at 14¾*d.*, also Stains at 7*d.* to 9*d.*—(*British Cotton Growing Assoc. Report*, October 23rd.)

* * *

BANANAS.—Jamaicas continue to be in fairly good demand, the Producers' prices advancing by £1 since last report, and Elders & Fyffes remaining unchanged at :—

	Delivered London.	*Provinces nearest Station.*
Jamaica Producers ..	£21 5	£21 0
Elders & Fyffes ..	22 5	22 0

Brazilian prices have advanced £1 since last report to £19 delivered nearest station.—(*West India Committee Circular*, October 26th.)

* * *

COPRA.—Copra is quiet but steady, West Indian f.m.s. being valued at £10 for spot, and £10 5*s.* to £10 7*s.* 6*d.* c.i.f. for November—December shipment. — (*West India Committee Circular*, October 26th.)

* * *

LIME PRODUCTS.—*Lime Oil.*—There is no demand for Handpressed with sellers at 40*s.* per lb. Distilled is neglected with sellers willing to meet the market. *Lime Juice.*—Buyers offer £4 10*s.* for Concentrated. Raw is neglected and unchanged.—(*West India Committee Circular*, October 26th.)